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the grains, *i.e.* the more molecular continuity is destroyed, the more is the light scattered and lost. May it not be so also with regard to moisture particles in suspension? The more subdivided they are, the greater number of limiting surfaces are there to scatter and impair the light.

But I am led to conceive that the intensity of light reaching us from the sky is occasionally influenced by another cause. Arago and others have pointed out, not only the familiar fact that clouds may be luminous, but that certain fogs may be phosphorescent, and they suggest that some such cause may account for certain abnormally light moonless nights; but I would go further and suggest that even clear sky may be phosphorescent also. We are familiar with various bodies often microscopic, in life or death, fitfully phosphorescent. Various noctilucæ render the ocean at times luminous, and light up the actual horizon. Are there no microcosmic organisms in higher strata of the ocean above us which behave similarly?

Again, phosphorescence of such organic matter as may well be in suspension in the atmosphere is thought to be connected with the presence of ozone, which in the atmosphere is a varying quantity. And, again, if it be actually true that it is often "darkest before dawn," then it is conceivable that there may be floating particles of the nature of phosphorescent sulphides or luminous pigments which lose their luminescence as the night proceeds.

A series of experimental photographic records seem to indicate that varying tracts of the night sky are occasionally to some extent self-luminous, but these results need further confirmation on clear moonless nights.

On some Attempts to Counteract by Instrumental Adjustments certain Effects of Refraction in Stellar Photography. By Arthur R. Hinks, B.A.

(*Communicated by Sir R. Ball.*)

Attention has recently been called to the possibility of counteracting to a large extent by instrumental adjustments the effects of refraction in displacing by a continually varying amount the field to be photographed. Dr. Rambaut has shown (*Monthly Notices*, 1896, vol. lvii. p. 50) that the variation with the hour-angle of the component in R.A. of the refraction can be met by suitable changes in the rate of the driving clock. When the polar axis of the telescope is adjusted to the true pole, the requisite change of rate for stars of small north polar distance becomes very large. Mr. Davidson has shown (*Monthly Notices*, 1897, vol. lviii. p. 4) that this difficulty can be overcome

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by adjusting the polar axis to the apparent pole as affected by refraction.

Neither Dr. Rambaut nor Mr. Davidson has given numerical details of the variation of the component in declination of the refraction. Yet in practice this component is the more important of the two, while the instrumental means of correcting for it are comparatively inadequate. The device adopted by Dr. Rambaut of introducing a change in clock rate, and consequent continuous trail in R.A., does away almost entirely with the need for small discontinuous hand corrections. But it does not appear that there is any instrumental device in use which will give a corresponding continuous trail in declination, and do for the following in this coordinate what the change in clock rate does for the R.A.'s.

I have been led, therefore, to examine the effect of a displacement of the polar axis of a telescope on the following in declination in the hope of finding a means of perfecting this, even at the expense of the following in R.A. The effect on the latter can then be compensated by modifying the alteration in the rate of the driving clock proposed by Dr. Rambaut.

I. *Effect on the following in declination of a displacement of the instrumental pole.*—Let the elevation of the instrumental above the true pole be e, and let the instrument be set for declination Δ. Let h be the hour-angle of the point to which the telescope is directed at any moment. It is easily seen that the declination δ of this point$=\Delta-e\cos h$, so long as e is small, and δ is not very nearly 90°.

$$\therefore \frac{d\delta}{dh}=e\sin h.$$

The projection on the sky of the intersection of the cross wires of the guiding telescope will therefore be moving in declination at the rate $e \sin h$. The values of this expression in seconds of arc per hour for various values of e and for every hour of hour-angle are given in the following table. The elevation $45''\cdot3$ is the adjustment proposed by Mr. Davidson to the apparent pole as affected by refraction in the latitude of Cambridge.

TABLE I.

Rates of Motion in Declination per hour, due to Elevation of the Instrumental Pole.

	Hour-angle West.					
Elevation.	0h.	1h.	2h.	3h.	4h.	5h.
30″	0·0	+2″·0	+3″·9	+5″·6	+6″·8	+7″·6
45·3	0·0	3·1	5·9	8·4	10·3	11·5
60	0·0	4·1	7·9	11·1	13·6	15·2
80	0·0	5·4	10·5	14·8	18·1	20·2
100	0·0	6·8	13·1	18·5	22·7	25·3
120	0·0	8·1	15·7	22·2	27·2	30·4

and so on.

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The displacement in declination due to refraction is $\Delta\delta = k \tan z \cos q$, where q is the parallactic angle. And if we put $\tan\theta = \tan c \cos h$, as in Mr. Davidson's paper, this becomes after some reduction

$$\Delta\delta = k \cot(\delta + \theta)$$

$$\therefore \frac{d}{dh}\Delta\delta = k \tan c \sin h \operatorname{cosec}^2 \overline{\delta + \theta} \cos^2 \theta$$

The values of this expression are given in the following table:—

TABLE II.

Rates of Motion in Declination per hour due to Refraction.

Decl.	Hour-angles. 0h.	1h.	2h.	3h.	4h.	5h.	6h.
°	″	″	″	″	″	″	″
0	0·0	+5·5	+13·2	+27·9	...	...	...
+10	0·0	3·8	8·5	16·5	+33·3	...	...
+20	0·0	2·8	6·3	11·4	20·6	+40·7	...
+30	0·0	2·3	5·1	8·8	14·7	25·2	+47·4
+40	0·0	2·1	4·4	7·4	11·6	18·0	28·7
+50	0·0	2·0	4·2	6·7	10·0	14·3	20·2
+60	0·0	2·0	4·1	6·5	9·1	12·3	16·2
+70	0·0	2·2	4·3	6·6	8·9	11·3	13·7
+80	0·0	2·5	4·9	7·2	9·3	11·0	12·2

We have now from Table I. the motion in declination of the projection on the sky of the cross wires, due to the elevation of the instrumental pole; and from Table II. we have the motion in declination of the guiding star, due to refraction. If these two quantities can be made equal the following in declination will be perfect.

It is convenient to plot the quantities in these tables as curves. If a tracing of one set is then laid over the other, it immediately appears, as is indeed plain from a comparison of the tables, that for polar stars, and for stars as far south as 20° N. decl. at small hour-angles, the effects of Mr. Davidson's proposed adjustment to the apparent pole are as valuable with respect to the following in declination as he has himself shown them to be in R.A. The outstanding drift in declination of the guiding star, which remains to be corrected by hand, is in general less than a second of arc per hour. The compensation fails, however, for equatorial stars and for stars of medium north declination at considerable hour-angles. In these cases some further adjustment is desirable.

Suppose for the moment that the instrumental pole could be adjusted with ease to any desired polar distance and hour-angle. It is clear that the effect of the adjustment to any hour-angle H would be to alter the rates given in Table I. for a

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star of hour-angle h to the corresponding rates for hour-angle $h-$H. To examine the effect of such an adjustment it is sufficient to slide the tracing of the curves from Table I. over the curves from Table II. by an amount corresponding to the value of H.

In this way it is possible to select for a star of given declination, which is to be photographed at a given hour-angle, a suitable displacement of the instrumental pole, such that over a considerable space the portions of the curves showing the variations in declination due to refraction and displacement of the instrumental pole respectively fit one another almost exactly ; for half an hour or more the following in declination will then be almost perfect.

The following table shows for various declinations and hour-angles suitable displacements of the instrumental pole approximately determined by this method.

Table III.

Values of e *and* H, *Displacements of the Instrumental Pole.*

	Hour-angle.					
Decl.	0^{h}.	1^{h}.	2^{h}.	3^{h}.	4^{h}.	5^{h}.
0°	80″	100″	160″	320″	...	...
	0^{h}	$0^{h}{\cdot}2$	$0^{h}{\cdot}7$	$1^{h}{\cdot}7$	...	...
+10	60″	60″	80″	160″	400″	...
	0^{h}	$0^{h}{\cdot}1$	$0^{h}{\cdot}3$	$1^{h}{\cdot}4$	$2^{h}{\cdot}9$	...
+20	45″	45″	70″	100″	180″	...
	0^{h}	$0^{h}{\cdot}1$	$0^{h}{\cdot}6$	$1^{h}{\cdot}3$	$2^{h}{\cdot}2$	...
+30	40″	40″	45″	80″	120″	240″
	0^{h}	0^{h}	$0^{h}{\cdot}4$	$1^{h}{\cdot}3$	$2^{h}{\cdot}1$	$3^{h}{\cdot}4$
+40	30″	30″	40″	60″	90″	140″
	0^{h}	0^{h}	$0^{h}{\cdot}5$	$1^{h}{\cdot}2$	$2^{h}{\cdot}0$	$3^{h}{\cdot}0$
+50	30″	30″	40″	50″	70″	100″
	0^{h}	0^{h}	$0^{h}{\cdot}4$	$1^{h}{\cdot}0$	$1^{h}{\cdot}8$	$2^{h}{\cdot}8$

Unfortunately the interest of this table is almost entirely theoretical. It is not possible in existing forms of instruments to alter the adjustment of the polar axis to suit each particular exposure, and there would be very considerable if not quite hopeless difficulties in the way of mounting an instrument with this facility of adjustment. Moreover, if the instrumental is much displaced from the true pole a very serious rotation of the field is produced, and the following would not be perfect except in the centre of the field. This point is considered in detail later.

For general photographic work, at all sorts of declinations,

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and, in the case of parallax work, at considerable distances from the meridian, a complete adjustment appears to be impossible. But for work on a zone of small breadth, such as astrographic chart work, where the photographs can all be taken near the meridian, the case is different. In the latitudes of English observatories the adjustment to the apparent pole answers fairly well, except for stars of large N.P.D.; but the adjustments given in the first column of Table III. will, I believe, be found even more satisfactory.

In low latitudes adjustment to the apparent pole is altogether wrong, except for work in the immediate neighbourhood of the pole. As an illustration of this, I give a table showing for the various observatories participating in the work of the astrographic chart, the elevation of the instrumental pole best suited to each case. The last column gives for comparison the elevation to the apparent pole.

	Latitude.	Zones (Decl.)	Suggested Elevation of Pole.	Elevation to Apparent Pole.
	° ′	° °	″	″
Greenwich	+51 29	+90 to +65	35	46
Rome	+41 54	+64 „ +55	30	66
Catania	+37 30	+54 „ +47	30	76
Helsingfors	+60 9	+46 „ +40	30	33
Potsdam	+52 23	+39 „ +32	30	45
Oxford	+51 46	+31 „ +25	35	46
Paris	+48 50	+24 „ +18	40	51
Bordeaux	+44 50	+17 „ +11	40	58
Toulouse	+43 37	+10 „ + 5	50	61
Algiers	+36 48	+ 4 „ − 2	45	78
San Fernando	+36 28	− 3 „ − 9	55	79
Tacubaya	+19 24	−10 „ −16	30	166
Santiago	−33 27	−17 „ −23	30	92
La Plata	−34 35	−24 „ −31	35	85
Rio de Janeiro	−22 54	−32 „ −40	20	138
Cape of Good Hope	−33 56	−41 „ −51	30	87
Sydney	−33 52	−52 „ −64	35	87
Melbourne	−37 50	−65 „ −90	50	75

The calculations were made for the middle of each zone.

II. *Corrections to the rate of the driving clock.*—Any elevation of the instrumental pole will necessitate corrections to Dr. Rambaut's clock rates, similar to those proposed by Mr. Davidson. The expression for the correction is

$$+ e \cos h \tan \delta.$$

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The following table gives the value of this correction when $e = 100''$. The corrections for the elevation actually chosen can thence be easily calculated.

TABLE IV.

Corrections to be applied to the daily Clock Rates proposed by Dr. Rambaut for an Elevation of the Instrumental Pole of 100″.

	Hour-angle.				
Decl.	0^h.	1^h.	2^h.	3^h.	4^h.
0°	$+0^s{\cdot}0$	$+0^s{\cdot}0$	$+0^s{\cdot}0$	$+0^s{\cdot}0$	$+0^s{\cdot}0$
+10	7·4	7·1	6·4	5·2	3·7
+20	15·2	14·7	13·2	10·8	7·6
+30	24·2	23·4	20·9	17·1	12·1
+40	35·2	33·9	30·4	24·8	17·6
+50	49·9	48·2	43·2	35·3	25·0
+60	72·6	70·1	62·8	51·3	36·3

This table is independent of the latitude, and can be used for any observatory. Dr. Rambaut's table is, of course, strictly applicable only to the latitude of Dunsink.

III. *Rotation of the field due to displacement of the polar axis.*—Let us now neglect for the time any effects of refraction and suppose that the stars are describing uniformly circles about the true pole. Let the instrumental pole P′ be at a distance e from the true pole P in hour-angle H.

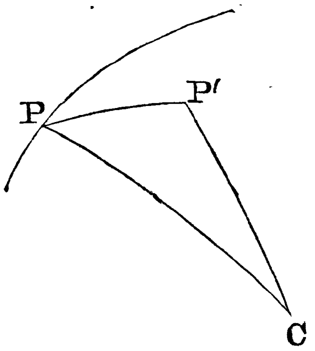

FIG. 1.

Let C be the projection of the centre of a plate in hour-angle h and instrumental polar distance p. Let the angle PCP′ be θ. The projection of CP′ on the plate will be what we may call the instrumental north and south line, while the projection of CP will be the true north and south line. And the angle θ varies with h. There will therefore be a rotation of the field during exposure measured by the value of $\frac{d\theta}{dh}$.

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We have

$$\sin(h-\mathrm{H})\sin e=\sin p\sin\theta.$$

Differentiating

$$\frac{d\theta}{dh}=\frac{\sin e\cos(h-\mathrm{H})}{\sin p\cos\theta}$$

and except for regions close to the pole we may put

$$\cos\theta=\text{unity, and }\frac{d\theta}{dh}=\frac{\sin e\cos(h-\mathrm{H})}{\sin p}$$

The values of this expression, in units of circular measure per hour, for the case $e=100''$ are given in the following table :—

TABLE V.

Rotation per hour of the Field when the Instrumental Pole is displaced 100″ *from the True Pole.*

	$h-\mathrm{H}$				
	0^h.	1^h.	2^h.	3^h.	4^h.
Decl. 0°	·000127	·000123	·000110	·000090	·000063
+10	129	124	112	91	64
+20	135	130	117	96	68
+30	147	142	127	104	73
+40	166	160	144	117	83
+50	198	191	171	140	99
+60	·000254	·000245	·000220	·000180	·000127

The trail of a star whose coordinates on the plate are $(\xi\,\eta)$ will then be $-\eta\frac{d\theta}{dh}$ and $+\xi\frac{d\theta}{dh}$ in the two coordinates.

For example, if $\xi=\eta=\tan 1°$, and the declination is +60°, the corresponding values of $-\eta\frac{d\theta}{dh}$ or $+\xi\frac{d\theta}{dh}$ are

$$\mp 0''\cdot 91 \qquad \mp 0''\cdot 88 \qquad \mp 0''\cdot 79 \qquad \mp 0''\cdot 65 \qquad \mp 0''\cdot 46$$

The effect, therefore, on stars near the edge of the field is by no means inconsiderable ; and displacements of the instrumental pole as large as some of those in Table III. are clearly out of the question except for short exposures or a very small field.

IV. *Rotation and distortion of the field, due to variation of the refraction with the time.*—Up to this point we have considered the effects of refraction upon a central guiding star and the consequent errors in the following. We have now to examine the effects upon the surrounding field.

The most appropriate refraction formulæ for use in this

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examination are those derived by Professor Turner for rectangular coordinates (*Monthly Notices*, 1894, vol. liv. p. 19).

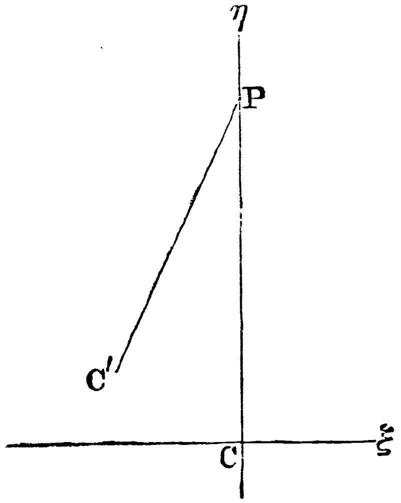

Fig. 2.

Let $C\xi$, $C\eta$ be the axes of coordinates of a plate, the projection P on the plate of the pole lying in $C\eta$. Let (X, Y) be the coordinates of the projection of the zenith ; β_0, the constant of refraction.

Then if $(\xi\eta)$ be the coordinates of the projection of a star's true place those of the apparent place as affected by refraction are $(\xi+\Delta\xi,\ \eta+\Delta\eta)$, where

$$\Delta\xi=\beta_0\left[X-(1+X^2)\,\xi-XY\eta\right]$$
$$\Delta\eta=\beta_0\left[Y-XY\xi-(1+Y^2)\,\eta\right]$$

neglecting small quantities of the second order.

If now the clock is rated to sidereal time, and the instrument is adjusted to the true pole, the path of the projection of C on the sky will be that of a star unaffected by refraction. Owing to the variation of the refraction with the hour-angle all the stars will trail upon the plate, and the expressions for the rate of trail in the two coordinates are

$$\frac{d}{dh}\,\Delta\xi=\beta_0\left[\frac{dX}{dh}-2X\frac{dX}{dh}\xi-\left(X\frac{dY}{dh}+Y\frac{dX}{dh}\right)\eta\right]$$
$$\frac{d}{dh}\,\Delta\eta=\beta_0\left[\frac{dY}{dh}-\left(X\frac{dY}{dh}+Y\frac{dX}{dh}\right)\xi-2Y\frac{dY}{dh}\eta\right]$$

These expressions may be conveniently divided into two :—

The first terms of each, $\beta_0\frac{dX}{dh}$ and $\beta_0\frac{dY}{dh}$, are the trail of a star whose true position unaffected by refraction would be at C.

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This is our guiding star, and these terms indicate a translation of the field as a whole.

The remaining terms of the expressions

$$-\beta_0\left[2X\frac{dX}{dh}\xi+\left(X\frac{dY}{dh}+Y\frac{dX}{dh}\right)\eta\right]$$

$$-\beta_0\left[\left(X\frac{dY}{dh}+Y\frac{dX}{dh}\right)\xi+2Y\frac{dY}{dh}\eta\right]$$

involve ξ and η, and indicate a distortion of the field.

The guiding star is displaced by refraction from C to C′, and the position of C′ is constantly varying. The telescope must be made to follow it, and the north and south line on the plate is always C′P. The angle between this line and CP, which we may call the original axis of η, will therefore be continually changing, and a rotation of the field results.

We have then to evaluate two separate effects, a rotation and a distortion of the field.

A. *Rotation of the field.*—If the angle CPC′ $=\phi$, and the N.P.D. of C is P, we have

$$\tan\phi=\frac{\beta_0 X}{\tan P}$$

very nearly, except for regions close to the pole. And ϕ is small.

$$\therefore\ \frac{d\phi}{dh}=\frac{\beta_0}{\tan P}\frac{dX}{dh}\ \text{nearly.}$$

If c is the colatitude, h the hour-angle of the centre of the plate, the coordinates of the projection of the zenith on the plate are

$$X=\frac{\tan h\sin q}{\cos(P-q)}$$

$$Y=\tan(P-q)$$

where $\tan q=\tan c\cos h$.

Then

$$Y=\frac{\tan P-\tan c\cos h}{1+\tan P\tan c\cos h}$$

and

$$\frac{dY}{dh}=\frac{\tan c\sin h\sec^2 P}{(1+\tan P\tan q)^2}$$

Also

$$\tan h=\frac{X\operatorname{cosec} P}{1-Y\cot P}$$

$$\therefore\ X=\sin P\tan h-\cos P\tan h\,.\,Y$$

and

$$\frac{dX}{dh}=(\sin P-Y\cos P)\sec^2 h-\cos P\tan h\frac{dY}{dh}$$

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From these expressions the values of $\frac{dX}{dh}$, $\frac{dY}{dh}$ were calculated for every hour of hour-angle from 0^h to 4^h, and for every 10° of declination from 0° to +50°.

Substituting then the values of $\frac{dX}{dh}$ in the equation $\frac{d\phi}{dh} = \frac{\beta_0}{\tan P}\frac{dX}{dh}$, the quantities of the following table were obtained:

TABLE VI.

Values of $\beta_0 \frac{dX}{dh} / \tan P$ *expressed in Circular Measure per hour.*

Decl.	Hour-angle.				
	0^h.	1^h.	2^h.	3^h.	4^h.
0°	·0000000	·0000000	·0000000	·0000000	·0000000
+10	108	114	133	176	280
+20	196	203	227	276	379
+30	284	292	313	356	443
+40	390	397	414	447	502
+50	·0000544	·0000544	·0000554	·0000571	·0000592

The trail of a star $(\xi\eta)$ due to this rotation will then be $+\eta\frac{d\phi}{dh}$ and $-\xi\frac{d\phi}{dh}$ in the two coordinates.

The rotation is in the opposite sense to that due to the elevation of the pole, and will therefore tend to counteract it. For declinations above 40°, with a suitable elevation of the pole, the compensation is fairly good, and the resultant rotation of the field is negligible. But near the equator the rotation due to the refraction is small, and that due to the elevation of the pole is able to produce its full effect.

B. *Distortion of the field.*—If we put

$$-\beta_0 2X\frac{dX}{dh} = A$$

$$-\beta_0\left(X\frac{dY}{dh} + Y\frac{dX}{dh}\right) = B$$

$$-\beta_0 2Y\frac{dY}{dh} = C$$

the trails of a star $(\xi\eta)$ tending to distort the field are at the rates $A\xi + B\eta$, $B\xi + C\eta$ in the two coordinates.

The values of A, B, and C are given in the following table to three significant figures, and are expressed in units of circular measure per hour :—

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TABLE VII.

Values of A, B, and C.

Decl.		Hour-angles.				
		0^h.	1^h.	2^h.	3^h.	4^h.
0°	A	+·0000000	−·0000426	−·000114	−·000297	−·00103
	B	·0000955	·000114	·000184	·000407	·00134
	C	·0000000	·0000709	·000190	·000494	·00171
+10	A	·0000000	·0000284	·0000700	·000154	·000384
	B	·0000560	·0000645	·0000976	·000186	·000458
	C	·0000000	·0000336	·0000858	·000199	·000532
+20	A	·0000000	·0000214	·0000497	·0000971	·000198
	B	·0000339	·0000391	·0000576	·000102	·000214
	C	·0000000	·0000178	·0000443	·0000970	·000228
+30	A	·0000000	·0000176	·0000388	·0000691	·000123
	B	·0000200	·0000236	·0000354	·0000614	·000169
	C	·0000000	·0000097	·0000241	·0000520	·000115
+40	A	·0000000	·0000156	·0000330	·0000549	·0000854
	B	·0000100	·0000127	·0000215	·0000393	·0000731
	C	·0000000	·0000047	·0000124	·0000280	·0000620
+50	A	·0000000	·0000147	·0000301	·0000469	·0000656
	B	·0000018	·0000041	·0000115	·0000255	·0000488
	C	−·0000000	−·0000011	−·0000043	−·0000129	−·0000329

From this table the rate of trail in each coordinate at any point of the plate may be easily calculated.

For in seconds of arc per hour

$$\frac{d}{dh}\Delta\xi = \frac{1}{\sin 1''}(A\xi + B\eta)$$

$$\frac{d}{dh}\Delta\eta = \frac{1}{\sin 1''}(B\xi + C\eta)$$

where (ξ, η) are the coordinates of any point on the plate expressed in circular measure.

Consider, as an example, the case of a plate 2° square, with centre 10° N. and 3^h from the meridian. If $\xi = \eta = \tan 1°$

$$\frac{A\xi}{\sin 1''} = -0''\cdot55 \qquad \frac{B\xi}{\sin 1''} = -0''\cdot67 \qquad \frac{C\eta}{\sin 1''} = -0''\cdot72$$

and

at the point		the rate of trail per hour is in ξ	in η
$\xi = \eta = \tan 1°$		$-1''\,22$	$-1''\cdot39$
$\xi = \tan 1°$	$\eta = 0$	$-0''\cdot55$	$-0''\cdot67$
$\xi = \tan 1°$	$\eta = -\tan 1°$	$+0''\cdot12$	$+0''\cdot05$
$\xi = 0$	$\eta = \tan 1°$	$-0''\cdot67$	$-0''\cdot72$

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A star at the first point will then be trailing inwards at the rate of nearly 2″ per hour; and during a long exposure the star discs in this and in the opposite corner of the plate will be very seriously distorted.

In this way was calculated the following table:—

Table VIII.

Values of $\frac{d}{dh}\Delta\xi$, $\frac{d}{dh}\Delta\eta$, *being Rates of Trail per hour in each Coordinate for a Star at the corner* $\xi = \eta = \tan 1^\circ$ *of the plate, for various Declinations and Hour-angles.*

Decl.	Hour angle.				
	0h.	1h.	2h.	3h.	4h.
	″	″	″	″	″
0°	−0·35	−0·56	−1·07	−2·54	−8·53
	0·35	0·67	1·34	3·25	10·98
+10	0·20	0·33	0·60	1·22	3·03
	0·20	0·35	0·66	1·39	3·56
+20	0·12	0·22	0·39	0·72	1·48
	0·12	0·20	0·37	0·72	1·59
+30	0·07	0·14	0·27	0·47	0·87
	0·07	0·11	0·22	0·41	0·84
+40	0·04	0·11	0·20	0·34	0·57
	0·04	0·07	0·12	0·24	0·48
+50	0·01	0·06	0·15	0·26	0·42
	0·01	0·01	0·06	0·14	0·30

These results appear to me to throw some doubt on Dr. Rambaut's belief that photographs suitable for accurate measurement can be obtained six hours or more from the meridian (*Monthly Notices*, 1896, vol. lvii. p. 52). I have not considered the case of hour-angles greater than four hours, because I have shown elsewhere (*Monthly Notices*, 1898, vol. lviii. p. 442) that, with reasonable luck in the matter of weather, it should never be necessary to take photographs for stellar parallax much more than four hours from the meridian. The importance of making every effort to work at the smallest possible hour-angle is evident from the table.

V. *General conclusions.*—Stellar photographs generally fall into one of two classes:—

A. Short exposures, less than 10m.

B. Long exposures, an hour and upwards.

The astrographic catalogue plates and plates for stellar parallax belong to class A.

It is extremely desirable that as little hand correction as possible should be given to these photographs, destined for the most accurate measurement. It will therefore be advisable to elevate

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the pole and adjust the clock-rates in order to ensure good following. For general work at varying declinations and hour-angles an elevation of about 60″ will probably be found best. For work in narrow zones, and near the meridian, other values of the elevation are found. Except near the equator the rotations of the field tend to counteract one another, and near the meridian the distortion is not very serious.

Astrographic chart plates, and plates intended for the parallax of clusters and nebulæ, fall into class B. For them it is a delicate matter to balance the respective merits or demerits of good following, absence of hand correction, rotation or distortion of the field. Near the equator and on the meridian it is best to adjust to the true pole, and sacrifice easy following to freedom from rotation, since distortion is fairly small. Far from the meridian distortion becomes so large that rotation is comparatively a minor ill. But here a small elevation of the pole has little effect on the following.

In high declinations the rotations compensate one another, and the distortions are small. It is here that the advantages of elevation of the pole are most fully realised, and there seems to be no reason why long exposure photographs should not be susceptible of very accurate measurement.

It is, however, useless to attempt to frame any general rules. Each case must be decided after a weighing of conflicting interests. But there seemed to be a want of numerical data on which to form a judgment. The tables contained in this paper were therefore calculated as a preliminary to the work which is to be shortly undertaken with the new photographic equatorial of the Cambridge Observatory; and they are now published in the hope that they may be found of more extended use.

Cambridge Observatory:
1898 *June* 4.

A Diagram showing the Conditions under which Observations for the Determination of Stellar Parallax are to be made. By Arthur R. Hinks, B.A.

(*Communicated by Sir R. S. Ball.*)

The diagram which is here described was constructed to facilitate the arrangement of the stellar parallax work to which the Director proposes to devote the new photographic equatorial of the Cambridge Observatory.

It shows for a star of any R.A. between the limits of declination 0° and +60°

a. The two days of the year on which the parallactic displacement of the star is a maximum.